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To begin the assembly of a coordinated, multi-parameter data base suitable for testing various approaches to prediction, Applied Physics Laboratory of Johns Hopkins, Cornell University, and Boston University, conducted a field campaign for 1-22 October, 1996. The Boston University team went to Tucuman, Argentina and set up an airglow imaging system to record the 6300 A airglow depletions that mark the boundaries of low latitude irregularity patterns. A successful series of measurements were made during the campaign. Optical observations at Arequipa, Peru were made. The range of observations and the dip latitude of Tucuman are shown in our figure. Positions relative to other stations such as Jicamarca and Santiago are also shown in this figure. The data are being reduced as of this time with interesting comparisons of phase and amplitude scintillation with optical and radar data. Localized differences are considerable so that on some days the occurrence of scintillation was different for stations 500 km apart.

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OFFICE OF NAVAL RESEARCH

A PLAN TO DEVELOP PREDICTIVE CAPABILITY FOR EQUATORIAL SCINTILLATION STORMS

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LONG TERM GOALS

Each new military communications satellite launched contains not only millimeter systems but 250 MHz transmissions. Fading on signals on the 250 MHz transmissions from FLEETSATCOM and on 1.2 and 1.6 GHz transmissions from the Global Positioning System is the focus of these studies. 250 MHz transmissions often show deep fading to noise levels in equatorial latitudes during certain months and during years of sunspot maximum. Fading due to ionospheric irregularities on satellite signals in equatorial latitudes could be mitigated by various techniques if forecasting of these irregularities was in place.

The basic goal of this grant is to determine the feasibility of forecasting phase and amplitude fading using both observational and modeling approaches. For example neutral winds in the ionosphere and lower atmospheric parameters have been suggested as determining factors in the occurrence of F layer irregularities. Can these be validated?

SCIENTIFIC OBJECTIVES

Our objective is to understand the physics of the development of irregularities in the equatorial region. With this in hand we aim to forecast the occurrence of scintillation of radio signals from communication and navigational satellites. We use measurements of various ionospheric parameters to determine the necessary and sufficient conditions for instabilities to develop.

THE OCTOBER 1996 EQUATORIAL CAMPAIGN

The concept of the predictive study is to involve several ONR sponsored groups, each with specialized expertise. The three groups involved are the Applied Physics Laboratory of Johns Hopkins, Cornell University, and Boston University, each with its own capabilities. The joint effort includes a large scale field program. If the integrated field program produces positive results, the data base will supply the basis for better models of the dynamics of irregularity development.

To begin the assembly of a coordinated, multi-parameter data base suitable for testing various approaches to prediction, the three institutions involved in the study planned and conducted a field campaign for 1-22 October, 1996; some data were taken after that. The Boston University team went to Tucuman, Argentina and set up an airglow imaging system to record the 6300 A airglow depletions that mark the boundaries of low latitude irregularity patterns. Working in conjunction with Professor J.R. Manzano of the University of Tucuman, a very successful series of measurements were made during the campaign. Optical observations at Arequipa, Peru. The range of observations and the dip latitude of Tucuman are shown in our figure. Positions relative to other stations such as Jicamarca and Santiago are also shown in this figure.

The data are being reduced. We are using the Julia radar data which indicates the existence of plumes developing along the longitude of Jicamarca. Data on wind patterns will be used extensively. Since the campaign month of October 1996 included a magnetic storm, we compared this storm with other data taken during the campaign from GPS stations and available thru the International GPS Service for

Geodynamics (IGS). The sites utilized include Arequipa, (Peru), Santiago, (Chile), Fortaleza, (Brazil), Kourou, (French Guiana), La Plata, (Argentina), and Brasilia, (Brazil).

There are differences between stations at various latitudes and longitudes for this South American grouping. The localized differences are considerable so that on some days the occurrence of scintillation was different for stations 500 km apart. On other days there was activity all across South America. For each station there were considerable day-to-day variations.

FORECASTING

Two types of forecasting or prediction can be the aim of the study. One is to use ground measurements in real time to determine (1) Is there scintillation activity that day? (2) At what height is the effective irregularity development? The latter aspect will tell how far from the magnetic equator fading will be observed. Another approach to forecasting is based on finding the necessary and sufficient conditions for various types of plumes to develop; this approach needs real time measurements of parameters such as horizontal and vertical electron density gradients, observations of gravity waves, and perhaps measurement of many atmospheric conditions below 100 km.

AASERT PROGRAM

In July 96, the imager situated at Goose Bay, was retrieved by Ms. Colerico and refurbished at Boston University. It was deployed to Tucuman, Argentina, in September 1996, in order to further study equatorial F-region irregularities (such as airglow depletions), which may cause loss of lock or fading of signal in GPS systems. In the past year Ms. Colerico has overseen the operation of the Arequipa, Peru imaging systems and she is now overseeing the operation in Tucuman as well. Data sets turned out to be fine for the October 1996 campaign and the data have been reduced in a preliminary fashion. A first look of the Tucuman data shows interesting examples of bifurcated airglow depletions as well as possible Brightness Wave Events such as those reported on in Colerico et al. 1996. Over the past year, Ms. Colerico has written a paper now published in the *Journal of Geophysical Research* (December 1, 1996) entitled "Coordinated Measurements of F-region Dynamics Related to the Thermospheric Midnight Temperature Maximum, " Colerico et al., 1996. This paper discusses Brightness Wave events observed from an all-sky camera site at Arequipa, Peru and their possible relation to the thermospheric midnight temperature maximum (MTM). The winds involved are of importance relative to forecasting irregularities. Temperature enhancement at the time of passage of the Brightness Wave would have associated with it a region of increased pressure which would serve to reverse the meridional wind. Ms. Colerico presented data related to these Brightness Wave Events at the annual CEDAR (Coupling, Energetics, and Dynamics of Atmospheric Regions) conference held in Boulder, Colorado in June 1996. Ms. Colerico also co-authored another paper which has been accepted for publication to the *Journal of Atmospheric and Terrestrial Physics*, entitled "Imaging science contributions to equatorial aeronomy: Initial results from the MISETA program," Mendillo et al., 1996.

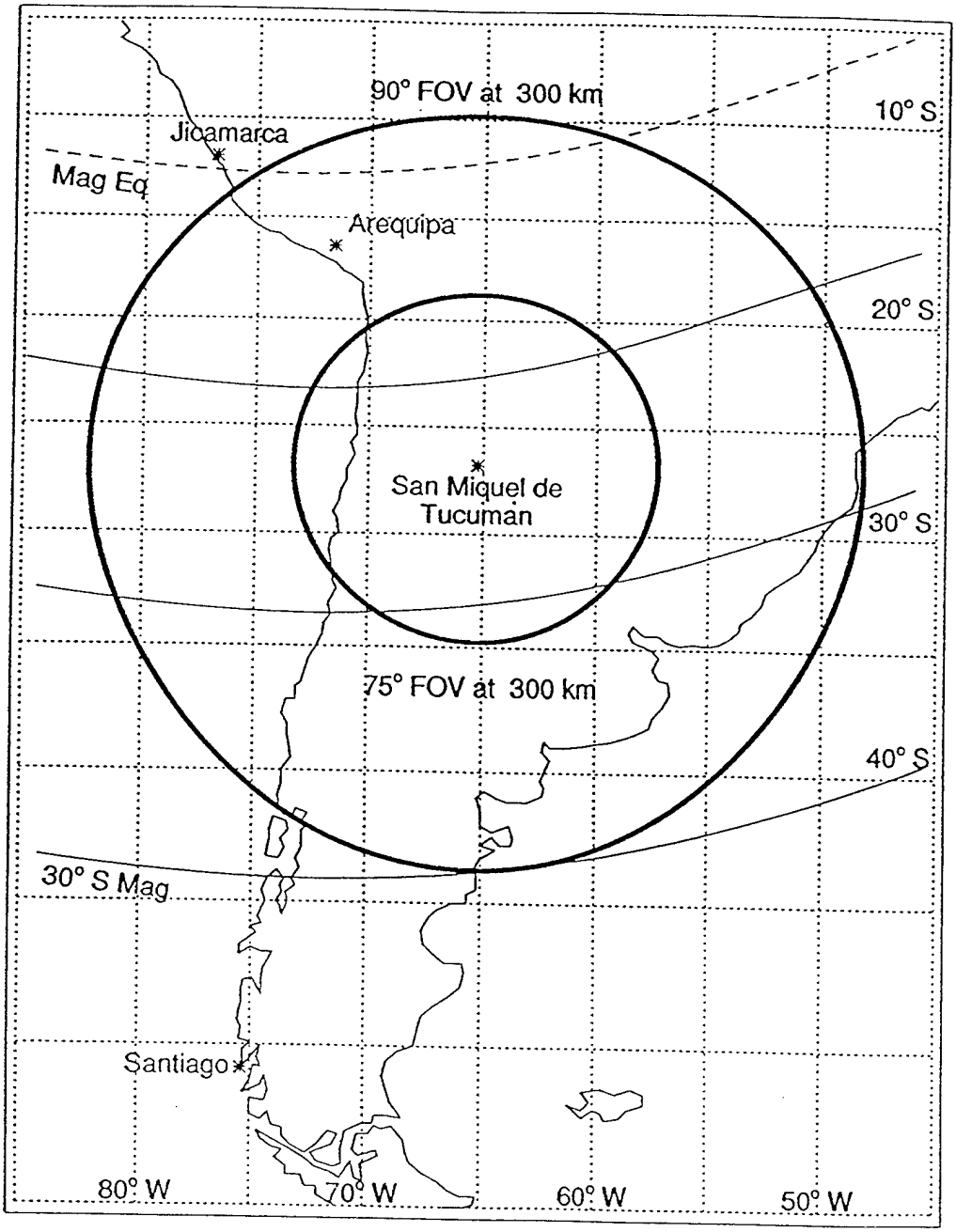
FUTURE STUDIES

As we have stated phase fluctuations as noted from an equatorial station such as Arequipa, Peru can be observed from Arequipa at various latitudes north and south of the magnetic equator. These tell whether

we have noted a thin layer of irregularities or a very high altitude plume. We then know how distant the effective turbulence will be felt. This is an important step in forecasting scintillation activity in a local area.

It is vital to correlate intense scintillation activity as determined by optical data and IGS analysis with loss of lock for GPS receivers. While some periods of magnetic storms noted at high latitudes did force the loss of lock, other periods failed to lose lock in sophisticated receivers. This study of available data will in turn be meshed with the equatorial studies of Cornell's receiver development and deployment. We shall be continue to determine if scintillation activity on one path can be used to forecasting scintillation activity on a series of paths.

Field of View From
San Miquel de Tucumán



For optical observations, Tucuman and Arequipa are equipped by Boston University to study depletions of electron density. The all sky observations show depletions of airglow in the F layer. The depletions are correlated with the occurrence of scintillations. Wind and GPS data are available from Arequipa with GPS data also available from Santiago. Radar data are taken at Jicamarca. The concept is to integrate the observations in order to assist in predicting day to day variation of scintillation intensity.